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Secure and Robust Watermarking Using Wavelet Transform and Student t-distribution

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Abstract

In this paper, we propose secure and robust data hiding algorithm based on hiding in random coefficients of Discrete Wavelet Transform and student t-distribution. The watermark image is scrambled to increases its security and robustness. Performance evaluation for robustness and imperceptibility of proposed algorithm has been made using bit error rate (BER) and peak signal to noise ratio (PSNR) value for different watermark and cover images such as Lena, Gibbon and Fruit images. The experimental results demonstrate that the proposed algorithm achieves higher security and robustness against JPEG compression as well as other attacks such as addition of noise, low pass filtering and cropping attacks compared to other existing algorithm using DWT coefficients.

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Keywords: Robust Copyright Marking; Information Security; Student t- Distribution; Discrete Wavelet Transform

1. Introduction

Nowadays media such as movies and images are produced and distributed digitally. It is usually simple to make copies of digital content. Consequently illegal pirate copies can be duplicated and distributed in large quantities. One way to deter authorized content receivers from illegally redistributing the media is watermarking[1]. If individual watermarks are contained in the digital media and a receiver is a pirate and redistributes it, the pirate at the same time distributes his identity. Thus a located pirate copy can be traced back to the pirate. The watermarked media should otherwise be indistinguishable from the original media content.

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There are basically three main objectives of watermarking that is to embed information without distorting the image, minimum perceptual degradation and extraction of information without any loss. This would ultimately lead to protect images with watermarking[2].

Common image transforms in image watermarking are Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT)[3], Discrete Wavelet Transform (DWT) or other multiscale transforms[4]. Properties like multiresolution, HVS (Human Visual System) modeling or spatial adaptivity has been proved helpful for better information embedding, efficient extraction of an image and in essence improved watermarking schemes. The transform coefficients are considered as channel noise and the hidden information is viewed as the signal to be transmitted through this channel[5]. Here we determine the distribution followed by the wavelet detail subband coefficients and then embed the information which follows the same distribution.

The best fitted distribution by the wavelet coefficients is student t-distribution. Basic motivations to choose t-distribution for the problem of watermarking is its ability of describing images with different statistical characteristics, the extraction of a simple test statistic and the efficient detection sensitivity compared to other known state of the art detectors, which are based on known statistical distributions[6]. Thus, in case of Student-t we expect that the nonlinear preprocessor will provide us with high detection sensitivity and improved robustness.

2. Proposed Algorithm

The algorithm is basically divided into two parts- embedding the information and extracting an original image.

2.1. Embedding Process

- Compute DWT coefficients of an image using 3- level subband decomposition.
- Determine the distribution followed by DWT coefficients of particular subband.
- Compute the parameters of best fitted distribution which is used as a key.
- Generate random numbers using this parameter.
- Add random numbers to DWT coefficients of a particular subband.
- Take inverse transform to obtain watermarked image.

2.2. Extracting Process

- Compute DWT coefficients of a watermarked image using 3- level subband decomposition.
- Generate random numbers of same distribution using key as a parameter.
- Subtract random numbers from DWT coefficients of a particular subband of watermarked image.
- Take inverse wavelet transform to obtain an original image.

In the embedding section, an image is first divided into wavelet coefficients either using haar wavelet or daubechies wavelet as shown in figure 2. Then determine the best fitted distribution of the subband detail coefficient of an image. It is clear from figure 3 that horizontal detail coefficients follow t-distribution[7].

Student t-distribution arises when estimating the mean of a normally distributed population in situations where the sample size is small and population standard deviation is unknown. Whereas a normal distribution describes a full population, *t*-distributions describe samples drawn from a full population; accordingly, the *t*-distribution for each sample size is different, and the larger the sample, the more the distribution resembles a normal distribution.

$$y = f(x/v) = \frac{\Gamma(\frac{v+1}{2})}{\Gamma(\frac{v}{2})}\frac{1}{\sqrt{v\pi}}\frac{1}{(1+\frac{x^2}{v})^{\frac{v+1}{2}}} \quad (1)$$

where v is the number of degrees of freedom and Γ is the gamma function.

Further add this random number to detail subband wavelet coefficients to obtain a watermarked image as shown in figure 4.

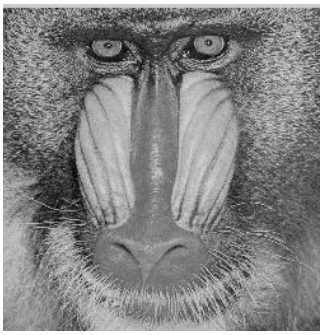

Fig. 1. Original image of baboon

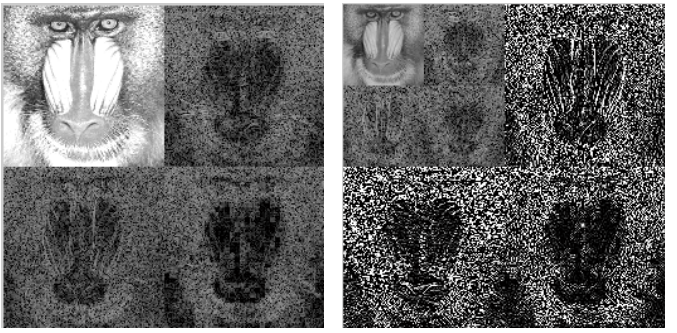

Fig. 2.(a) First level decomposition; (b) Second level decomposition

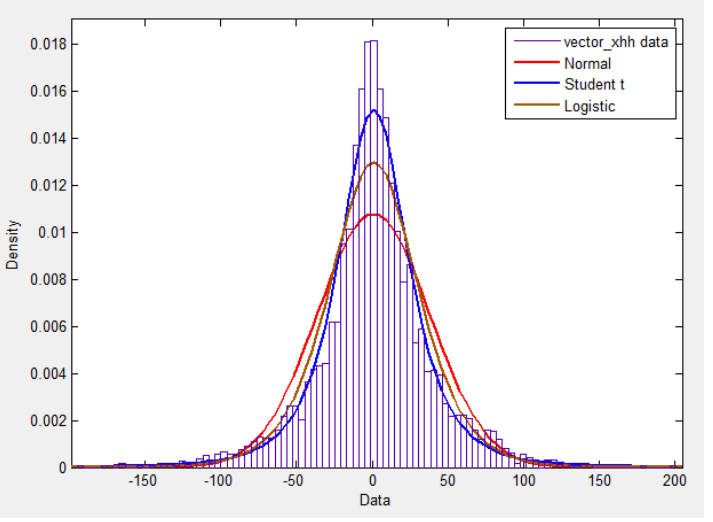

Fig. 3. Various distributions applied on samples of detail coefficients

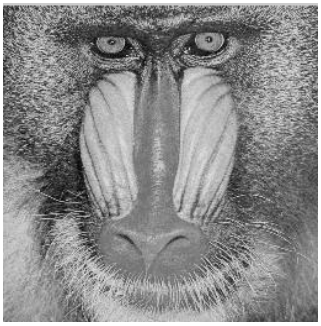

Fig. 4. Watermarked image of baboon

3. Results and Discussion

Performance evaluation of the proposed data hiding algorithm that is discussed in above section is carried out by determining the values of PSNR and BER for different images. Table I and table II shows the BER and PSNR value of an image baboon and fruit having resolution 256×256 at different level of decomposition respectively.

Table 1. MSE and PSNR value of an image Baboon

Components	Degree of Freedom	MSE	PSNR
First Level Decomposition			
Horizontal	2.34045	0.6033	50.3255
Vertical	3.55612	0.3290	52.9583
Diagonal	1.95598	0.9286	48.4523
Second Level Decomposition			
Horizontal	2.92127	0.1014	58.0687
Vertical	3.87722	0.0673	59.8532
Diagonal	3.32696	0.0859	58.7890
Third Level Decomposition			
Horizontal	3.12799	0.0127	67.0944
Vertical	3.53077	0.0190	65.3335
Diagonal	4.97459	0.0029	73.4626

Table 2. MSE and PSNR value of an image Fruit

Components	Degree of Freedom	MSE	PSNR
First Level Decomposition			
Horizontal	1.74816	1.2479	47.1691
Vertical	1.59571	1.5045	46.3570
Diagonal	1.65952	1.3908	46.6981
Second Level Decomposition			
Horizontal	1.59191	0.4071	52.0337
Vertical	1.62057	0.4790	51.3274
Diagonal	1.8216	0.3495	52.6965
Third Level Decomposition			
Horizontal	1.66289	0.0845	58.0636
Vertical	1.84132	0.0635	60.1047
Diagonal	1.59967	0.0576	60.5253

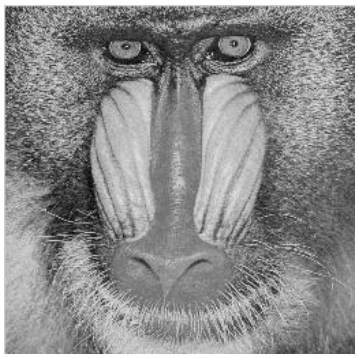

Fig. 5. Extracted image of baboon

Fig. 6. Original image of fruit of size 256×256

Fig. 7.(a) Watermarked image; (b) Extracted image of fruit

Robustness accounts for the capability of the watermark to survive signal manipulations. Generally BER is used to measure the robustness of embedding method. Low values of BER signify that proposed algorithm results in enhanced robustness. Imperceptibility refers to the perceptual transparency of the watermark which is measured by the PSNR value. High PSNR value (>39.5dB) signifies low distortion as it makes more difficult to detect the presence of copyright mark, thus improving imperceptibility.

4. Conclusion

This paper has discussed the method of embedding random numbers in an image using student t-distribution. So this method of watermarking is proved to be the very powerful tool for the purpose of copyright protection. Also this technique is more secure and can be potentially useful in robust copyright marking.

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